Journal

OF THE

West Australian Natural History Society

WITH WHICH IS INCORPORATED

The Mueller Botanic Society.

DR. W. MICHAELSEN

ON THE

FAUNA OF SOUTH WESTERN AUSTRALIA

(ILLUSTRATED).

No. V.—JULY, 1908.

Perth:

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ERRATA.

Page 8, line 9 from bottom for "iepidloptera" read "lepidoptera"

Page 10, line 5 from bottom for "are" read "being"

Page 13, line 22 from top for "unpassable" read "impassable"

Page 13, line 23 from top for "as" read "and"

Page 17, line 25 from top for "Australian" read "Australia"

Page 24, line 11 from top for "wsell" read "swell"

Translated by Fraülein Gertrude Michaelsen and
Fraülein Käte Michaelsen.

No. V.—JULY, 1908.

Page 6, line 3 from bottom for "epidiascope" read "episcope"

Page 10, line 5 from bottom for "Ford" read "Bond"

Page 13, line 23 from bottom for "impassable" read "impossible"

Page 19, line 23 from bottom for "Paris" and "Rome" read "Australia"

Page 21, line 3 from top for "Australia" read "Rome"

Page 24, line 11 from bottom for "well" read "very well"

Journal

OF THE

West Australian Natural History Society

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The Mueller Botanic Society.

First Report upon the Publications on the "Hamburger südwest-australische Forschungsreise, 1905,"

BY

Professor Dr. W. Michaelsen, Hamburg.

Translated by Fraülein Gertrude Michaelsen and Fraülein Käte Michaelsen.

No. V.—JULY, 1908.

Table of Contents.

West Australian Natural History Society.

(With which is incorporated the Mueller Botanic Society.)

No. 5.—JULY, 1908.

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THE

Western Australian Natural History Society.

REPORT FOR THE YEAR 1907-8.

LADIES AND GENTLEMEN,

Your Council has much pleasure in submitting the Annual Report and Statement of Receipts and Expenditure for the year ending the 30th June, 1908.

The year commenced with a Credit Balance of £95 3s 8d. The actual Receipts amount to £23 8s. 0d., including the Government grant of £15 for 1907. The Expenditure amounts to £36 9s. 1d., leaving a Credit Balance of £82 2s. 7d.

The number of members is at present 51, of whom 11 are honorary. This is less than the preceding year by 8. The decrease is due to resignation and non payment of subscriptions. No new members have been elected during the year, but several have been proposed and will be ballotted for at the next meeting. It is sincerely hoped that members will take a greater interest in the Society and that every effort will be made to induce friends to join.

The Council has met five times, and the Society has only held four meetings. Owing to the re-arrangements necessitated by the building of the new Art Gallery, the Lecture Room in the Museum was not available for holding meetings in 1908.

The following papers were read :—

"Two New Orchids" and "Biological Notes on Acacia celastrifolia," by Mr. O. H. Sargent.

The Secretary, Mr. G. P. Morison, resigned his position in November, and Mr. G. W. Bradshaw was appointed to his place.

A number of the JOURNAL was issued in November, and a special number by Dr. Michaelsen is in preparation.

GEO. W. BRADSHAW,

13th July, 1908. SECRETARY.

STATEMENT OF RECEIPTS AND EXPENDITURE

OF THE

Western Australian Natural History Society,

FOR THE YEAR ENDING 30th JUNE, 1908.

RECEIPTS.

	£	s.	d.	£	s.	d.
To Balance from Last Year—						
Cash	1	0	9			
W.A. Bank	94	2	11			
				95	3	8
,, Members' Subscriptions				8	8	0
,, Government Subsidy				15	0	0
				£118	11	8

EXPENDITURE.

	£	s.	d.	£	s.	d.
By LIBRARY—						
Purchase of Books, W. W. Froggatt	0	12	6			
Angus & Robertson ...	1	0	6			
Hamilton	0	7	0			
Russell (Binding) ...	0	5	6			
Hamilton	0	4	0			
				2	9	6
,, PRINTING—						
V. K. Jones & Co.	1	3	0			
do.	0	5	6			
do (Journal) ...	8	8	0			
do. (Reprints) ...	0	7	6			
do. (Blocks) ...	0	14	0			
				10	18	0
,, SALARIES—						
Secretary, Mr. Morison	5	0	0			
do. Mr. Bradshaw ..	10	0	0			
				15	0	0
,, PETTY CASH—						
Postage, Stationery, Attendants, &c.				6	18	1
,, Bank Charges				1	3	6
,, Cash in hand				3	10	2
,, Balance in W.A. Bank				78	12	5
				£118	11	8

We have compared the above Statement of Receipts and Expenditure, with the Books and Vouchers produced, and certify the same to be correct.

Perth, W.A., July 13th, 1908.

J. W. LANGSFORD
H. R. COOMBS
} AUDITORS.

First Report upon the Publications on the "Hamburger südwest-australische Forschungsreise, 1905."

By Professor Dr. W. Michaelsen (Hamburg).

The invertebrate fauna of Western Australia and its shores has been rather neglected by the Zoologists. Whilst the other States of Australia with a more ancient culture for a long time past have explored the fauna of their territories, this younger State of the Commonwealth has as yet had neither the time nor the necessary funds for this scientific task. It is true, the few scientific men in official positions have been busy enough in this way, and published estimable contributions to the knowledge of the Western Australian fauna. Several private specialists have collected here, and published accounts of their collections. But still there has been wanting a general investigation uniformly considering all classes and orders of the animal kingdom. This could be performed only by the united work of a large staff of specialists.

Several zoo-geographical problems in which I was interested made me feel intensely this defect in our knowledge of the distribution of animals, and induced me to undertake personal faunistic researches in W.A. Together with Dr. R. Hartmeyer, of Berlin, we carried out these investigations during the colder season of 1905, from the beginning of May till the middle of October. The valuable support we got from the Government of W.A., and from the scientific circles of the State, facilitated our task in a high degree, and the great hospitality we enjoyed throughout made it a very agreeable one. At the 167 stations from Albany and Bunbury in the south, to Denham, Shark Bay, from Fremantle and Geraldton, on the coast, as far as Kalgoorlie and Day Dawn in the interior, we got rich collections of all kinds of animals, as well from continental localities as from marine ones. These collections have now been distributed among a great number of specialists of different nationalities, authorities in their departments. The elaborated accounts of these collections are to be published in a collective work "Die Fauna Südwest-Australiens Ergebuisse der Hamburger Südwest-Australischen Forschungsreise, 1905, Verlag von G. Fischer, in Jena," edited by W. Michaelsen and R. Hartmeyer.

As these publications may be of particular interest in Western Australian scientific circles, I willingly agreed to the proposition of Mr. Bernard H. Woodward, Director of the Western Australian Museum, to give reports on these and other publications about this scientific expedition.

Die Tierwelt Südwest-Australiens und ihre geographischen Berichtigen ("The Fauna of South-Western Australia and its geographical relations") by Dr. W. Michaelsen, Zu : Mitteil Geograph. Ges. Hamburg, Bd. XXII.

This treatise is principally based upon the general observations made during the travels of 1905. Only one class of Western Australian animals could be dealt with in full after having been thoroughly studied, viz., the Oligochæta (Earthworms). This class is of particular importance in questions of geographical relationships and in the former history of continents. The treatise is divided into two main parts, the first dealing with the continental fauna, the second with the marine fauna.

The Continental Fauna of South-Western Australia.

The first chapters, dealing with Orography, and Geology, Rainfall, Hydrography, and Vegetation, are of an introductory character. They need not be treated here particularly, as their contents are compiled from other papers. The following chapters are an original elaboration and may be given in full as a translation from the German text.*

The Fauna.—The character of the fauna in a particular district is controlled by geological, historical and physiographical factors. Every smaller or greater relationship, every natural species, family, etc., has grown out of more archaic forms in a certain close circuit. If we find it later on in an extended district, we must suppose that it has spread itself from the confined district of its origin over this greater area. But this spreading cannot go on equally in all directions. The concerned group of animals is limited in one direction (terrestrial animals by the sea, fresh-water animals by the desert), while it finds an easy way in another. These possibilities of spreading alter in the course of geological periods. An older group of animals found an easy way for spreading where younger groups found an impassable barrier. The fauna of a certain district is dependent in the first place on its geological history, with the differing possibilities of spreading and immigration. While these historical factors give to a certain extent manifold variety, the physiographical factors, viz., the general conditions of existence in the particular district, effect a sort of selection. Some of the animals pressing in from outside find a favourable condition of life, take possession of the district and attain

* The translation has been made by Fraülein Gertrude Michaelsen and Fraülein Käte Michaelsen, to whom I am greatly indebted.

a definite status. To other animals the conditions are not so favourable, and even if they do succeed in gaining a foothold they have a more or less miserable existence. It does not follow that these ill-favoured conditions are altogether an obstacle to evolution. In many cases they may effect the development of new forms. If the advantageous places for a certain species of animal are rare, scattered, and isolated, and if thus the continued exchange between the inhabitants of different places is interrupted, the conditions for the formation of varieties are given, and if there be sufficient length of time, of new species. In any case the individual number of these step-children of the land, and with it their influence upon the general character of the fauna, is correspondingly small.

The way the spreading and the settling down of a species occurs is in the first place dependent on the mode of living, on the medium in which the animal in question lives, and the capacity for enduring certain peculiar circumstances, which come in question during the migration. It is clear that a terrestrial animal, for which the salt of the sea is deadly, requires other conditions for migration than a littoral one, for which the salt of the sea is not injurious, but rather a necessity for its existence. To the one the sea is an unconquerable obstacle, to the other a comfortable way of migration. Therefore, it is necessary that the whole material must first be separated and these biological circumstances investigated, if we would really come to useful results. Even small systematic groups do not give a clear picture of the geographical relations, if different modes of living are represented in them. In the following I will explain the fauna of South-Western Australia divided into biological groups.

Dry-land Animals.—Under this name I understand all animals, which are able to exist without fresh water throughout life, to which the contained water of solid food is sufficient for existence.

With its vast expanse of plain, poor in water, where there is no rain during a long period of the year, it is no wonder that these dry-land animals are very abundant in South-Western Australia. In vast districts the collecting zoologist does not find any other animals at all. Here the entomologists and the herpetologists alone find any interest in collecting. Innumerable are the millipedes, the spiders and those terrestrial insects whose whole development takes place on dry land, but before all the ants and the termites, whose dome-shaped buildings ever form a feature in the landscape. There are also a number of wee springtails, silver-fish, beetles, crickets, bugs, cicadas, and lepidloptera. The latter are generally small moths, while the larger butterflies are rather rare. Probably that is dependent on the period of growth of most plants, which is a very short one, regarded from the standpoint of a food supply, and is only sufficient for the development of smaller forms. The wood-lice seem to be rather scarce in the south-west of Australia. As there is no sufficient reason to be found for this in the physiography of the land, the cause of this paucity is perhaps to be looked for in the historical circumstances.

In second line are to be regarded the land reptiles, the lizards and the snakes. The abundance of different species and of grotesque forms is surprising to everyone, who compares it with the scantiness of our German fauna. We were able to find eleven different species in a small district (in the neighbouroood of York) on a short afternoon stroll. That is more than the whole number of reptiles in the German fauna.

As to the geographical relations of the dry-land animals of South-West Australia it is to be noticed that they do not find any barrier passing across the whole Australian Continent. Even those, to which the real desert with its scanty spinifex and acacia vegetation does not give much support for life, find a passable bridge in the broad tract of scrub-land, which continues along the south through the whole width of the continent until the forest land of South Australia and Victoria is reached. Even now the extension of these animals may be going on over the whole width of Australia, and an exchange with those of the Eastern States. We must not expect the fauna of the dry-land animals of S.W. Australia to be essentially different from that of Eastern Australia.

Fresh-water Animals.—In this chapter I will only consider such animals as need, during their whole life, fresh water. All animals which require fresh water temporarily, be it in the grown-up state or during the egg-period, I consider to be amphibious (see below). The animals I discuss here, need a constant fresh-water locality, that does not even dry up in the rainless season. Through this restriction the number of this group of animals is very limited; for very many of the forms, generally considered as fresh-water animals, are able to persist, through the forming of cocoons or statoblasts, which so to speak, bridge over the temporary drying up of their life-element.

South-Western Australia is very poor in perennial fresh waters. In the greater part of this province there are not any. Where there are larger accumulations of water, which last throughout the rainless season, the water is, without exception, salt. Only in the South-Western corner of our Province, limited by the isohyeta (rainfall) of 16 inches (a line that goes from the south point of Shark Bay to the east end of the Stirling Range), there are perennial fresh waters, small lakes, bogs, and running streams. But these waters are comparatively small. Big, deep, geologically old lakes, which would serve as a magazine for fresh water fauna, are wanting. In discussing the fauna of Lake Baikal (1) I have traced the surprising richness of this big 1800-metre deep lake, rich in endemic and partly phyletically very old forms of animals, to the geological age dating from the Devonian period, and its constancy in the course of the later geological periods. Lakes geologically younger have a correspondingly poorer and phyletically younger fauna. Even respectable lakes, as Teletzky Lake in the

(1) W. Michaelsen: Die Fauna des Baikal-Sees. In: Verh. Naturw. Ver. Hamburg, 3 Fg., IX., p. 43.

north of Altai (2) and the bigger lakes of the Alps, cannot be compared in their richness and the phyletical age of their endemic fresh water animals with Lake Baikal. Therefore it is not to be wondered at that the small fresh water lakes in the S.W. of Australia, which have not in all probability any great geological age (in spite of the geological age of their bottom), are only in possession of very few perennial animals. In fact, our earnest investigations have only produced a very poor result—some few fish, some few snails, one single species of shell, some small crustaceans, some species of river crawfish, one leech and three different species of Oligochæta. Characteristic is the uncommonly small number of the lacustrine Oligochæta. Being a specialist in them, I have, of course, eagerly searched for these animals, and the result of the six months' work was three species. Considering that in the near neighborhood of Hamburg there are 28 species, the lacustrine Oligochæta of S.W. Australia can be called a very poor one, even if one considers that as yet only the smaller part of all the South-Western Australian species has been found.

With respect to geographical relations the fresh water animals of S.W. Australia were a disappointment. The small area where animals can be found is thoroughly isolated, separated through about half the width of the whole continent from all similar places. Therefore, it might be expected that this biological group would have the strongest faunistic peculiarities. As far as the material has been examined, the contrary proves to be the case. The beautiful river crawfish, *Cheraps*, belongs to a genus which appears also in other States of Australia; the Trematodes found in these river crawfish belong to the genus *Temnocephala*, which is spread over a large part of the world, appearing in New Zealand, the Eastern States of Australia and South America. Of the three Oligochæta two (*Pelodrilus*) are very nearly related to some species of New Zealand, South Africa, and South Siberia, while the third (*Pristina longiseta*, Ehrbg.) is a cosmopolitan species, appearing in South and North America, in Europe and Africa (3). I, being a specialist, ought not to have been surprised at this result, being in accord with the facts stated by myself some time ago: "While the terrestrial Oligochæta show as a rule a very limited area for the species and the genera, as well as the sub-families and families are also limited in a most characteristic manner, the lacustrine Oligochæta are distinguished (without taking into consideration the transport by man), by an uncommonly wide distribution of certain species as well as of genera and families." (4). To what this strikingly vast distribution of the many fresh water animals is due, whether

(2) See W. Michaelsen: Eine neue Haplotaxiden-Art und andere Oligochæten aus dem Teletzkischen. See in nördlichen Altai. In: Verh. Naturw. Ver. Hamburg, 3 Fg. X., p. 1.

(3) As well as India.

(4) W. Michaelsen: Die geographische Verbreitung der Oligochaeten, Berlin 1903, p. 3 and 4.

the causes of spreading are owing to the carrying by water birds, flying over vast districts from one fresh-water pool to another which is especially favorable to certain lacustrine animals, or whether other circumstances are in question, is not yet cleared up. For the Oligochæta it is very probable that the lacustrine forms are generally phyletically older than their terrestrial relations, and that, for the most part, for example the species of S.W. Australia, belong to the phyletically oldest groups, which got their vast distribution in a geological period far anterior. It is still questionable whether these observations can be applied to other groups of animals, for instance to snails or shells.

Amphibious Animals.—Under this heading I will discuss those animals which for a certain time need fresh water, and for a certain time can do without it, firstly, those animals whose larva lives in the water, while the imago is always or sometimes to be found on dry land, such as frogs and many insects, gnats, aquatic beetles, dragon flies and others. Furthermore, those kinds of animals, generally pointed out as pure fresh water animals, living in the water as larva and imago, but whose eggs and statoblasts, closed up in chitinous cocoons or bare, are able to endure a period of dryness, as for instance the Phyllopods and Daphnids, the fresh water Sponges and Bryozoa. Finally there are those animals which in whatever state they may be, that is either as animals grown up or as eggs, can dry up without losing their vitality, as the microscopic Infusoria, the tiny Tardigrada and the Trichina-like Nematodes.

The conditions for the life of these amphibious animals are not only found in perfection in the extreme South-West, with its heavy rainfall, but also in the region of light rain in the districts of the scrub forests. Real amphibious animals, tadpoles, larvæ of flies, and Trichoptera, Phyllopods, Planarians, etc., we found in the smallest puddles of fresh water as far as we went up into the interior part of the country, at Yalgoo and Boorabbin, and even in the gold districts of Day Dawn and Kalgoorlie. The most remarkable thing as regards fresh water localities was the comparatively rich fauna of small rain water puddles high up on the top of a bare granite hill at Boorabbin. These puddles in the very shallow hollows of the granite, measured at the most 10 feet across, and were in the deepest spots scarcely 3 inches deep. With the burning sun beating upon this granite hill, one would suppose that these puddles would be dried up within a few days, and yet very many little animals were here enjoying existence. There was a crowd of flies' larvæ, tiny Copepods and Ostracodes, as well as larger Phyllopods (Branchipus and Eulimnadia) in them, and heaps of black Planarians were crawling at the bottom. How did these animals come into these very isolated small puddles? Doubtless they or their eggs are carried there by birds or water beetles, which fly far about from one fresh water puddle to the next, which may be miles away.

For these animals, too, there is no barrier between S.W. Australia and the other parts of the Continent. Even if the real desert does

not afford the necessary conditions for the existence of these amphibious animals, they find a bridge in the broad tract of scrub land with its few water pools to make their way from the West to the East. Frogs, for example, appear in the oases of Central Australia.

The number of these amphibious animals, if by far less plentiful than that of the dry-land animals, is still very great. We could distinguish six different species of Batrachians (frogs,[1] toads), perhaps there are even more. Furthermore many flies, several species of dragon flies, Trichoptera, and aquatic beetles, numerous species of smaller and bigger crustaceans and so on.

The geographical relations of these amphibious S.W. Australian animals I cannot discuss at present. The point in question seems to be mostly the wide distribution of the genera and species. For instance, the Trichoptera, collected by me belong to four genera; the first occurs also in Europe, the second in Europe and in the Malay Archipelago, the third in Brazil and New Zealand, and the last n Brazil.

Salt-water Animals.—The animals in salt water are uncommonly rare. In a puddle containing only little salt artificially deepened at the edge of the dried up Hannan's Lake, near Kalgoorlie, we found only two species of Phyllopods of the genera Apus (?) and Branchipus, and many larvæ of a species of fly; in the concentrated salt water of a lake on the Island of Rottnest we found only myriads of fly-larvæ, and one little beetle, that very likely got in there by accident. Upon the whole salt is not unfavourable to the development of animal life. We can see that in the rich fauna of the sea. For while the steady cold of the polar seas, as well as the regular warmth of the tropics, produce abundant animal life, we find a less abundant fauna in the so-called temperate zones, with their change from warm to cold. Also the intermediate condition between the almost constant salt of the sea and the constant fresh water of rivers is very unfavourable to animals. The estuaries of the coastal districts, as well as the salt lakes of the interior, undergo very strong fluctuations in the proportions of the salt, a great change between the concentration and evaporation during the dry season, and the dilution during the rainy time. There are only a few "euryhaline" species, which can stand this change, and so they increase in such places, free from any struggle for existence and with plenty of rich food, to an enormous extent as regards the number of individuals.

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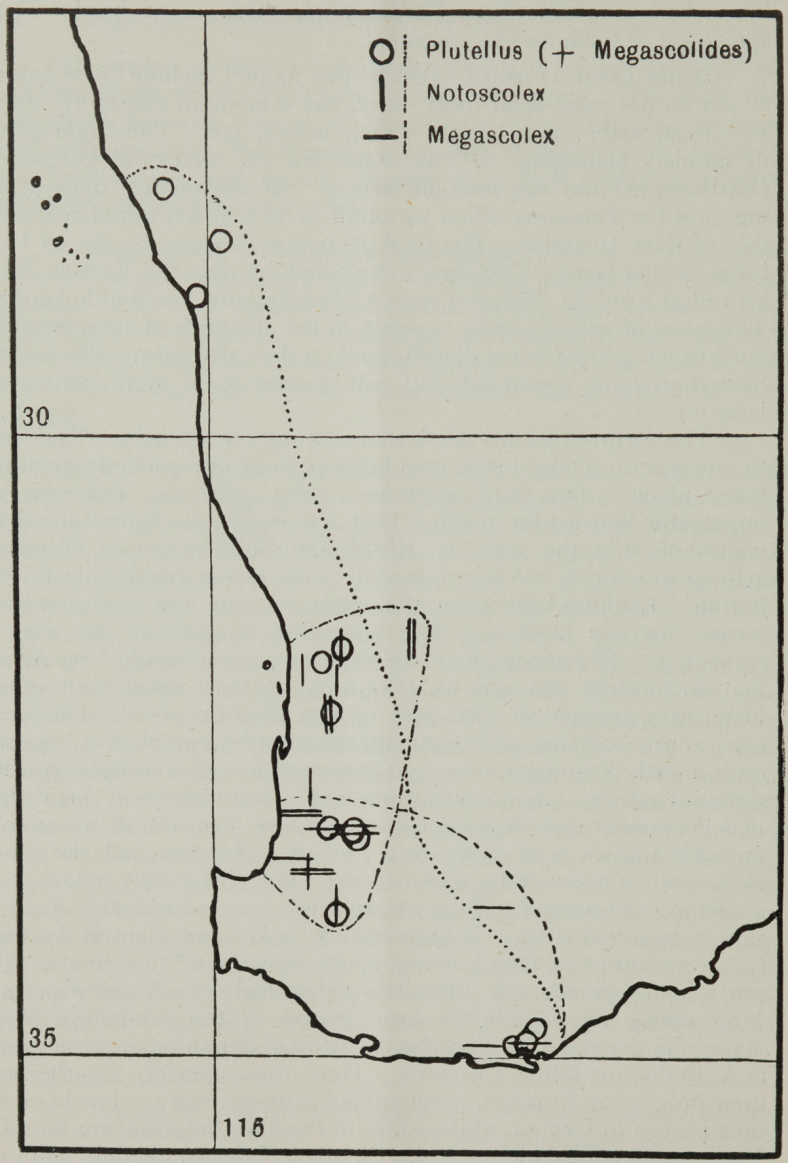
(1). Among the frogs one species struck us by its diminutiveness. Animals grown up were scarcely larger than the youngest European grass-frogs, when just developed from tadpoles. This diminutiveness is perhaps a peculiar accommodation to the ephemeral nature of many fresh water localities. To the short duration of these fresh waters corresponds a shortening of the development of the larvæ living in the water, and finally to this short period of development for the larvæ the diminutiveness of the grown up animals may be due.

As a rule these animals have an uncommonly wide distribution of genera, if not of species. Consequently as a characteristic of special regions, such as that of S.W. Australia, they need not therefore be taken into consideration. Furthermore, there is no barrier to the spreading of them on the continent.

Moist land Animals.—Under this name I include those animals which do not need clear fresh water, but a medium constantly wetted with fresh water, moist earth, rotten leaves, etc. The larger groups of animals belonging to this class are the terrestrial Oligochæta (Earthworms) and the land-planarians. Of the smaller ones I only mention the Peripatus which we found to be a closely allied species to that of East Australia. The land planarians belong, as far as I can judge, to the Genus *Geoplana*, distributed far over the Eastern States as well as over the Malayan region, New Zealand, and South America. This class of animals seem to agree in the methods of spreading (but not in their geographical distribution) to the earthworms. The latter I have thoroughly examined and will discuss them more particularly later on.

The earthworms are the farmers among the animals. They stick to one place. Only slowly, step by step, their independent spreading takes place. Dry land stretches, salty grounds, and seas are unpassable barriers for them. That is how the configuration of the continents and the seas, as the climatic circumstances of passed geological periods, are ascertained by their recent geographical distribution. Looking back from the latter we can now construct those former barriers hindering their spreading as well as the ways of spreading. The geographical distribution of the South-West Australian earthworms can give us, therefore, the best instruction of the historical-geographical character of this district. Our collection of earthworms contains 34 endemic species, besides a number of imported ones, mostly European forms. These endemic species belong to five different genera. As no earthworm was hitherto known in this district it is no wonder that all these species are new ; for the distribution of endemic species is as a rule very limited. However, all the genera also occur in other States of Australia. The phyletically oldest genus *Eodrilus*, represented only by one species, has a world-wide distribution in scattered areas ; in Queensland, N.W. and Central Australia (in oases) are to be found living single species of that genus. The other four genera are Plutellus, Megascolides Notoscolex, and Megascolex, the phyletically lower genera of the sub-family Megascolecinæ derived from Eodrilus. The chief dominion of these genera is Australia, including Tasmania. Here these genera, together with their progenitor Eodrilus, predominate without rivalry. Furthermore, they prevail in Ceylon, while a few of them as outposts are found in India, in New Zealand, and the Chatham Islands, as well as in the west of North America. S.W. Australia, therefore, belongs certainly to the Australian region of terrestrial Oligochæta, and has no special character of its own nor nearer connections with the nearest extra-


Plutellus (+ Megascolides)
Notoscolex
Megascolex
30
35
115

Australian districts, than the Indo-Malayan and the Ceylon districts. However, in slight details the South-Western Australian terrestrial Oligochæta show some peculiarities, just as those of the other States of Australia somewhat differ from one another. Firstly, the absence of the genus Diporochæta in S.W. Australia is remarkable; that genus you find so often in Victoria and Tasmania, and to a smaller extent in dispersed colonies in North Queensland, India, and in New Zealand. S.W. Australia is in its fauna of terrestrial Oligochæta somewhat like certain districts of New South Wales and perhaps also of South Australia. The different sub-districts of S.W. Australia show some certain peculiarities amongst them : The three principal genera Plutellus, Notoscolex and Megascolex (the small fourth genus Megascolides may be joined to Plutellus) have quite distinct limited dominions. Plutellus, combined with Megascolides, occupies the whole district from Northampton to Albany as far as its hydrographical conditions permit the existence of earthworms ; Notoscolex is only to be found in the middle part from Perth-York to Bridgetown, Megascolex only in the south part from the Harvey to Albany. These different dominions are by no means caused by the physiographical characteristics, as the degree of moisture of the soil within their limits is not parallel to the lines of equal annual rainfall. For instance, the dominion of Megascolex contains the locality of Broome Hill, the farthest outpost in the dryer inland, besides the very rainy stretches of the southern coast. These dominions are only decided by the historical geographical data, except on their common inland or N.E. border, which is fixed by the general dryness. I will discuss these historical geographical data in the next chapter.

Erdgeschichtliche "Conclusions."—S W. Australia has only been connected, as regards the important distribution of endemic terrestrial Oligochæta (earthworms), with the Eastern States of the Australian Continent, from which they have spread. We can perceive three different phases of settling. The phyletically oldest genus of Megascolecinae, Plutellus (Megascolides) occupied the whole district. The phyletically younger genus, Notoscolex, and the youngest Australian genus, Megascolex, could only take possession of smaller districts, which differed from one another. At the time of the immigration of these younger forms the passage to these districts seems to have been a rather difficult one, for apparently the spreading obtained from only few species, which resolved themselves into a larger number of younger species while spreading over a certain district As the starting points for the spreading of these two younger genera are very different, the question is whether these temporary but distinctly separated settlings have come on different roads into our district. Probably the configuration of the surface has been, in earlier geological periods, much more complicated, be it that the Continent has run out towards the S.W. into separated peninsulas, or that temporary isolation of certain sub-districts by separation of bigger isles has occurred.

The new knowledge about the further distribution of the genera of earthworms which concerns the whole of Australia, confirms my former opinion that there are between Australia and the southern points of the other continents (Africa and South America) no relations which can be declared to depend only upon a direct connection between them. There is no need for the supposition of an ancient great Antarctic Continent which connected Australia, Africa, and South America as some scientific men still suppose. In fact certain relations between the southern points of these continents can not be doubted; but they do not depend upon a direct connection of the land. They consist on the one part of euryhaline forms for which the salt sea is no barrier, which can be transplanted by the west wind drift over the stations on the different isles lying there between one continent and another (littoral Oligochæta: Lumbricillus, Marionina, Enchytraeus, Michaelsena, and Microscolex); and on the other part of ancient forms, which were pushed away by the phyletically younger forms, developing and spreading in the larger continents of the northern hemisphere and of the tropics. Such a form is the Eodrilus of S.W. Australia, whose generic companions have survived in the southern points of Africa and South America, and on the islands of New Zealand, New Caledonia and Madagascar, which were separated in early geologic times from the continents Even in some out of the way districts north of the Equator some species of this genus occur, as, for example in the Cordilleras of Central America and Mexico as well as in the Kameroon mountains. The distribution of these forms in Australia does not entail the immigration of them from the South. They are altogether wanting in the well searched districts of Tasmania, Victoria and New South Wales (South Australia cannot be included here because of the slight explorations made there), that is to say just in the corner of the continent, which must have formed the connection with this problematic antarctic continent. The Australian localities, as well as the others of this genus, are typically ancient. Species of this genus are found in the oases of Central Australia, in the background behind the vast dry district in S.W., N.W., and N.E. Australia, as in other continents pressed against the wall by the enormous development of phyletically younger genera. These Eodrilus outliers might be put in connection with the other species of this world-wide distributed genus by an earlier bridge between Australia and S.E. Asia. For the explanation of their origin there is no need for the building up in vast oceans of enormous continents.

In the same manner the phyletically younger endemic earthworms of Australia point out a direct land connection between Australia and South East Asia. The almost identical generic relationships of the earthworm fauna of Ceylon (not in the same period in India) and Australia affords further proof. One could be tempted to join Ceylon to the Australian earthworm region. Only the existence of some rare Indian and Indo-Malayan forms in Ceylon authorises a

separation of the Cingalese earthworm region. This relation of Ceylon to Australia is the more striking, as we miss in the intermediate Malayan Archipelago, even in New Guinea, every trace of the phyletically older Megascolecine genera, characteristic of Ceylon and Australia. On the other hand this wide separation between the two districts of the elder Megascolecines, Australia and Ceylon, is easily explained, if we examine carefully the earthworm fauna of the intermediate districts. Here in the Indo-Malayan region the younger offspring of the Megascolecine line prevails, that is the genus Pheretima. Like other sub families this genus Pheretima is very prolific in spreading.[1] It has pushed away or even exterminated in the Indo-Malayan district the elder Megascolecines, its ancestors.

The separation of Australia and Ceylon from the Indo-Malayan region was only just in time to save them from being overwhelmed by the genus Pheretima, and thus kept alive one of the most interesting Oligochæte fauna. It is still to be mentioned that some of the phyletically oldest Megascolecine genera have spread far beyond the Indo-Malayan and Cingalese regions, the Genera Plutellus and Megascolides up to the Cordillera of North America (and even into Pennsylvania ?), the genus Diporochæta to India and on the other hand over New Zealand and into the Chatham Isles.

If we now regard the earthworm fauna of New Zealand we see that this territory must have been detached in a geological period very remote from the separation of the continental masses of Australian and S.E.Asia. Only some of the oldest Megascolecine genera Diporochæta and Megascolides, have been able to spread over this district ; the latter found the South Island of New Zealand already detached and could only take possession of the North Island. In the detached New Zealand region there then developed out of the most archaic genus Eodrilus two special genera Maoridrilus and Rhodedrilus, which do not occur outside this district. Except that there is another Eodrilus-offspring, the sub-family Octochætinæ, which only exists in India (and Ceylon ?) and is quite extinct in the intermediate districts. As there is no trace to be found of these Octochætines in Australia, where they would have been protected from the destructive competition of the younger Pheretima, we must suppose that the connection, New Zealand and the Continent of Asia, very early broken, did not touch Australia. New Zealand may very likely have had some connection with the Indo-Malayan district, perhaps through New Guinea. The appearance of some old Australian forms (Megascolides and Diporochæta) is not contrary to this view. These genera

1. This power of colonising is demonstrated by the exported forms. In many places of the old world Pheretima species have been imported with plants by man. These imported forms have settled themselves and pushed away the endemic earthworms of these places, at least out of all cultivated localities. For instance I find in a rich new collection from Madagascar (certainly not belonging to the Pheretima region) more species of Pheretima than of endemic Malagasy genera. Certain circumstances which cannot be discussed here, show with certainty that these Pheretima species are not indigenous in Madagascar but imported.

in earlier times much more widely distributed, may have arrived by a longer route over New Guinea to New Zealand, if not directly as a one-sided transmission of the fauna.[1] Such one-sided transitions of animals without mutual exchange are not infrequent and have often taken place in the Indo-Malayan-New Zealand districts, with their strongly varied and changed configurations in the course of the geologic periods.

THE MARINE FAUNA OF THE SOUTH-WEST COASTS.—PHYSIOGRAPHY: In this part, too, I shall begin with a description of the physiographical peculiarities important to the animals.

The coast of S.W. Australia is for the greatest part a level coast ("Ausgleichsküste") with monotonous long stretches of sands. Only in some places the older rocks come to the surface on the coast and cause steep cliffs. In the youngest geological districts, for instance at Cottesloe, some miles to the north of Fremantle, these rocks and cliffs are formed of Pleistocene limestone. But where the Australian tableland comes right down to the sea, as on the south coast at Albany, gneissic and other primitive rocks form steep stretches along the coast.

There are many considerable *bays*. These are especially marked and very intricate on the South coast. Easterly from Cape Leeuwin, where the much worn edge of the Australian table-land is washed by the sea, you often find almost circular bays, nearly enclosed from the sea by rocks stretching far out into the ocean, as for instance Princess Royal and Oyster Harbours at Albany. Ordinary bays are to be found where the rounded limestone hills form simple promontories as in the case of Geographe Bay behind Cape Naturaliste. Where these lines of hills stretch far into the sea, deeper but less rugged bays are formed as in Cockburn Sound, which opens to the north behind the crest of Garden Island, which in recent times has been separated at the south point from the continent. The estuaries of the larger rivers also increase the number of bays. A peculiar formation seems to me to occur in the greatest of all bays of W. Australia, Shark Bay. Behind a steep cliff, rising from the deep sea, (which, not far from the coast is 40 fathoms deep) to the height of more than 300ft. above the level of the sea, the land slopes down inland into a shallow flat valley with several slight longitudinal ridges. It has the appearance as if at the breaking down of the coastline on the outside, the new front of the remaining land had risen and at the same time had exerted pressure upon the hinterland, causing a sink-

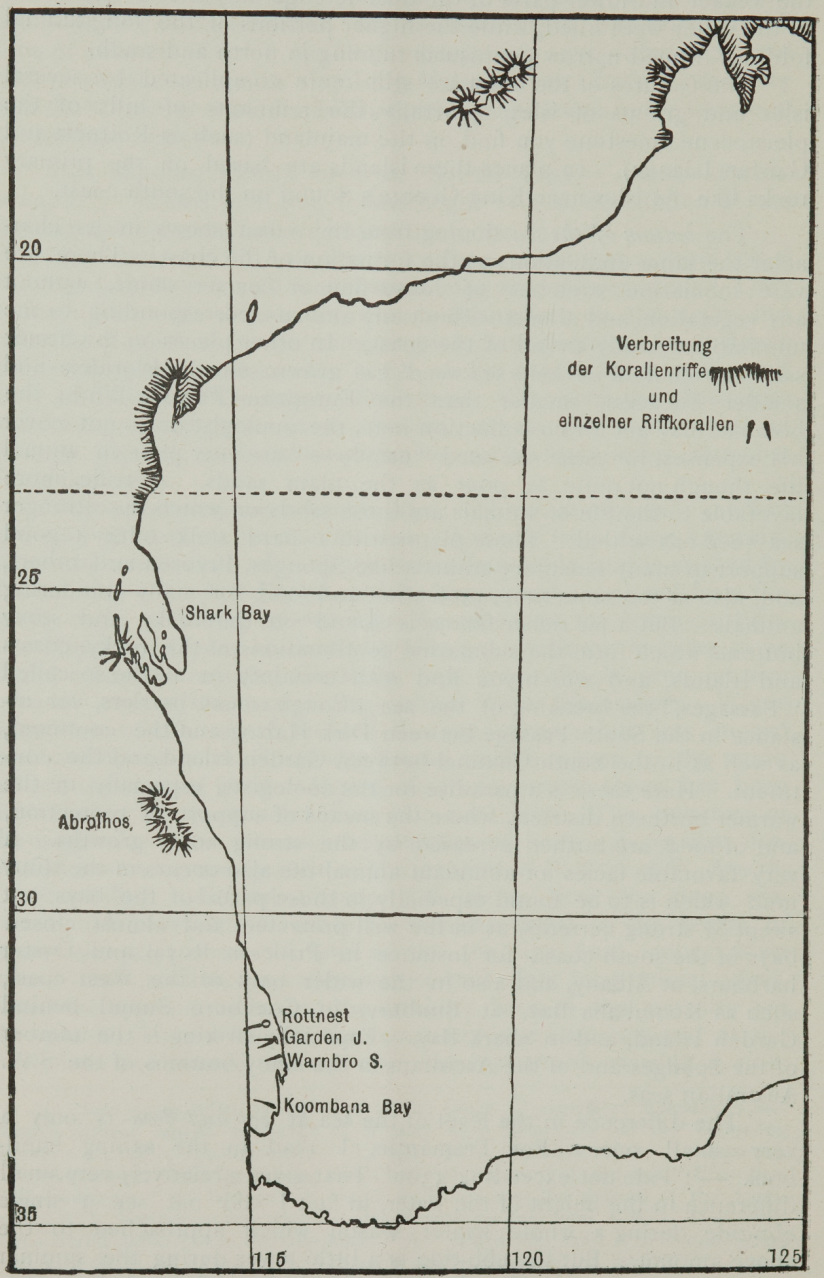
1. Such a one-sided transmission of the fauna ("einseitige Faunenzuschiebung") without mutual exchange of it may have gone on in the following manner:—A part of the continent "A," perhaps a peninsula of it, is separated, the connecting land bridge sinking down beneath the level of the sea. This part of the continent "A" becomes an island, on which only live animals of the continent "A." Farther on this island coalesces with another land "B." The fauna of the island derived from the continent "A" enters the land "B" and mixes itself with the fauna of this land; but not a single animal of the land "B" attains to the continent "A."

ing and a slight folding of the latter. On the sea breaking through the weaker and lower parts of the outside edge only the deeper parts of the valley were filled, while the higher portions of the longitudinal foldings formed narrow peninsulas running in north and south.

The features of the coast are still more complicated by several isles and groups of isles, generally the remnants of hills of the pleistocene limestone you find on the mainland (such as Rottnest and Garden Islands). In places these islands are based on the primary rocks like the isles near King George's Sound on the south coast.

The *bottom of the sea* sloping from the coast shows in its character the same undulations as the formation of the coast. There are vast submarine stretches of loose fine or coarser sands, without any vegetation, and almost without any animals, corresponding to the uninhabited sandy strand of the coast. In other places on the firmer sands a rich flora of kelp sea-weed has grown, mostly Florideæ and smaller Fucaceæ, smaller than the European *Fucus*. While the botanist may get a rich collection here, the zoologist does not cover his expenses, for these sea-weed "meadows" are very poor in animal life, though not quite as poor as the plain sands. A trifle more favorable to the life of animals are those sands on which the stronger sea-weed has settled. These plants with a hard stalk offer a good support to many sedentary animals like Sponges, Bryozoa and others, and, also at the same time, protection and food for many wandering animals. But a far richer fauna is found on the rocky and stony bottoms which form the submarine continuations of the rocky coasts and islands, and which you find with certainty in all the so called "Passages," the breaking of the sea through rocky barriers, for instance in the South Passage between Dirk Hartog and the continent, as well as in the South Channel between Garden Island and the continent. Here there is a paradise for the zoologists, especially in the warmer northern districts, where the means of support, of protection, and of food, are further increased by the strong coral growths. A very favorable facies for abundant animal life also occurs in the slimy mud which is to be found especially in those parts of the bays not swept by strong currents, as in the well protected and almost closed bays of the south coast, for instance in Princess Royal and Oyster harbours, at Albany, and also in the wider bays of the West coast, such as Koombana Bay, at Bunbury, in Cockburn Sound behind Garden Island, and in Shark Bay. Especially striking is the number of the Sponges and of the Ascidians in the slimy bottoms of the S.W. Australian seas.

The difference in the level of the sea at *ebb and flow* is only a very small one. For Fremantle, I read in the sailing handbook :—"Tide not exceeding 33in." That gives a relatively very small difference in the height of the water, in fact I did not see a single ebb-tide during a whole winter season which approached to the above amount. But the ebb-tide is a little lower during the summer months, when the prevailing land-winds aid the reflux of the water.


20
25
30
35
115
120
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Verbreitung
der Korallenriffe
und
einzelner Riffkorallen
Shark Bay
Abrolhos
Rottnest
Garden J.
Warnbro S.
Koombana Bay

It is remarkable that they do not have a half day's cycle of tide but a whole day's in S.W. Australia. Through this practical absence of tides the zoologist misses good opportunities for working—for on other coasts collecting during the lowest ebb-tides is the most productive—but also finds that what in other districts would produce a rich and thoroughly characteristic fauna is here very barren.

THE FAUNA.—As the prevailing trend of the Western Australian coast is from north to south, we must look for the principal geographical relations of its littoral fauna in the same directions. These are all that can be talked about before the exact scientific examination of the collections. For in only these two directions the fauna, corresponding to the variations in temperature of the water, shows striking differences in its general habits. The discussion of these geographical relations falls naturally into the questions concerning the antarctic, the sub-antarctic and the northern sub-tropical fauna; but these questions cannot possibly be discussed without further preparation. While that part of the fauna declining towards the tropical region contains, as a rule, very characteristic and striking forms, the part towards the colder regions of the south is characterised by the absence of these tropical forms. All I can at present state is that there are certain forms, which point to the antarctic or sub-antarctic relations of the southern districts, and which characterise the southern fauna in a distinctive manner, such as the Tunicates (*Colella.*) But the real discussion of this question must be postponed until after a more exact study of the collections has been made.

The question of the direction of the tropical and the sub-tropical fauna of the coasts of Western Australia remains. Even the most superficial study of the collections shows that the northern part is richer in typically tropical animals than the southern; that the characteristic warm-water-fauna gets much poorer in the south, and by-and-bye some of its characteristic groups disappear altogether. Let us consider, firstly, the collections from Shark Bay, the most northern point of our district, situated in about the middle of the western coast of Australia, and cut by the parallel between 25 degrees and 26 degrees of southern latitude. Shark Bay has a fauna nearly tropical in character. There are in first line several species of reef corals, which give this character to the bay, several species of Turbinaria, partly growing to large, imposing structures, and medium sized Pocillopora, several Astræidæ, usually small, one Fungia, &c. A dead, worn piece of a Madrepora, too, was found on the beach. But these corals do not appear here, as far as I know, as reef-builders. The richest patch of corals noticed, is that on the south coast of Surf Point at the south end of Dirk Hartog, where there were scattered colonies of Pocillopora and Astræidæ, whose locations were separated from each other by several yards. Whether these colonies approach more closely at the northern side of Surf Point, which is washed by the breakers, as I presume to be probable, must be left undecided, because the violence of the breakers made it impossible

to study that part of the coast. According to the literature at my disposal the most southern of the real coral reefs of the West Australian coast are to be found near Anderson Point, which is somewhat to the north of the tropic of Capricorn, and more than two degrees north of the northern end of Shark Bay. Other tropical forms of Shark Bay are some composite thrifts (Zoantharia), horn-corals (Gorgonidæ) and a number of Alcyonaridæ of the genera Sarcophytum, Dendronephthya and Nephthya. Some specimens of the latter, which grow in a cauliflower-shaped colony of more than two feet in diameter, are the most gigantic Alcyonidæ I ever saw. Of the other tropical animals of Shark Bay I may mention the small pearl shell (Meleagrina imbricata), which maintains a small colony of pearl fishers at Denham on Shark Bay. The large true pearl shell (Meleagrina margaritifera) is not endemic in the district of Shark Bay; but the Government attempts at introducing it have apparently been very successful.

If we follow the coast southward, we soon see a rapid diminution of these tropical forms. Here again we examine the reef corals, which are so highly sensitive to the temperatures of the surrounding water. Some of the Shark Bay corals, as, for instance, the genus Fungia, were not to be found further south. The genus Pocillopora has still some small scattered colonies on the isle of Rottnest, in the Fremantle district. Some small Astræidæ still go a little way further south, the farthest, as far as we know, being in the Warnbro Sound, in 32 degrees south latitude. The most southerly was a certain species of Turbinaria. We not only found this species at Shark Bay and in the Fremantle district, near Garden Island, but as far south as Koombana Bay, off Bunbury, in about 33 degrees south latitude. A lucky haul brought up several living fragments of an apparently very magnificent growth. Through this discovery the known frontier of the distribution of the reef-corals (not the real coral reefs) on the Western Australian coast is carried some good six degrees of latitude to the south. At this point the real southern termination of the reef-corals, probably, is nearly reached. The change in the fauna is still increased by the disappearance of all the forms of animals, whose existence is due to the existence of the corals. The number of these is very considerable; for the corals form large and strong shelters, which offer a special *facies* at the bottom of the sea for a very peculiar fauna. I will only speak of one example of the commensuals of the corals, a Polychæt worm, a species of Eurythoe. The specimens from Turtle Island (near Port Hedland, on the North West Australian coast) are very magnificent, at the most, 18 cm. long. Several specimens from Shark Bay are all smaller than the least of those of N.W. Australia, being at the most 7 cm. long, while the largest specimens taken at Fremantle were only 2 cm. long. No Eurythoe has been found further southward.

The warm water forms, independent of the corals, also show a speedy diminution to the south. We found only one single horn-

coral (Gorgonia) so plentiful in the Shark Bay, a certain Melithæid (Mopsella) in occasional specimens further southward off the cliffs of Rottnest in the Fremantle district, and in Oyster Harbour at Albany, on the south coast. Just as striking is the disappearance of the Alcyonidæ, which, in Shark Bay, grow to such splendid proportions. Further southward we only found one single, miserable specimen, a Nepthyid some few cm. long.

While the West Australian coast shows us a very simple and rather regular change from the tropical to the temperate zone, the faunistic picture becomes much more complex it we regard the group of isles lying to the west of the coast, viz., the Houtman's Abrolhos. These isles are situated at a distance of about 40 sea miles westward of Champion Bay, between 28·15 degrees and 29 degrees of south latitude. An exact description of these isles and of their physiographic faunal relations has been given by R. Helms. [1] After studying the zoological materials of the Abrolhos in the Western Australian Museum in Perth, I can confirm Helms' assertion about the marine fauna of the Abrolhos. The isles are abundantly surrounded by well developed coral reefs and show otherwise in their fauna a thoroughly tropical character, and that just opposite and only 40 miles distant from a coast of which the fauna can scarcely be called sub-tropical. In order to find a similar tropical fauna alongside the coast we must travel about 6 degrees of latitude to the north, far beyond Shark Bay, up to the tropic of Capricorn. How is this contrast between the faunal character of these islands and the coastal district at the same degree of latitude to be explained? What is the foundation of this tropical character of the Abrolhos? Perhaps the currents of the sea have a certain influence in differentiating the fauna. The southern part of the Western Australian coast is much influenced by the cold S.W. current, which, branching off from the sub-Antarctical west wind drift flows along this coast. The northern part of the Western Australian coast is, on the other hand touched by a warm current of the sea, which coming down from the north coast of Australia, rounds off the north-western corner of the Continent and then goes on to the south. According to the map this warm current does not even reach as far as Shark Bay. However, in fact, we must suppose that it goes further southward and prevails over the cold south current unto that point where the coast recedes a little to the east (Steep Point, a little south of Shark Bay). Then, if one follows the real southern direction of the current, one finds that deflected at an acute angle from the coast it strikes the Abrolhos Islands. The supposition of a northern current going so far south makes the tropical character of the Abrolhos comprehensible, and at the same time the colder temperature of the waters of the coast lying opposite would be explained by a branch of the cold south current going along the coast. Thus two con-

1. R. Helms: "Houtman's Abrolhos," in Journ. Dept. Agriculture, Western Australia, vol. 5, part 1. 1902, pp. 33 to 55.

trary currents pass by one another, a cold southern near the coast and a warm northern out to seaward.

But the circumstances become still more complicated if one regards another circulation of the sea water, that is the "cold swell" (*kalter Auftrieb*) rising from the depth of the sea, which is generally found on the sub-tropical west coasts of continents. On the Western Australian coast, too, there are east winds prevailing, as a rule, for a considerable part of each day. These push the warmer surface water seaward, and so cause the rising of the colder bottom water to replace the driven water at the surface. This rising of the colder bottom water, the "cold wsell" takes place quite close to the coast, and of course influences mostly the line of the coast and its fauna. On the surface the originally colder water soon gets a higher temperature, so that by the time it has been driven by the east winds over the space between the coast and the Abrolhos it has grown warm. In this manner, too, the difference between the marine fauna of the Abrolhos and that of the coast may be explained.

The effect of the rising "cold swell" is also very likely kept back from these isles by the peculiar configuration of the sea bottom in the district of the Abrolhos. The sea between the coast and the isles is very shallow, upon the average about 20 fathoms, at the most 30 fathoms. Not until further seaward than the Abrolhos, just as on the continental coast further to the north and to the south, does the bottom of the sea slope quickly to a much greater depth. The isles and reefs of the Abrolhos lie on the top of a slightly submerged promontory. The rising of the "cold swell" in consequence of the surface water being driven seaward, can naturally only take place where the bottom of the sea rises directly to the continental coast, not just in front of this group of isles. For here the driven surface water gets filled up by the surface water of the shallow sea lying behind. This water driven away from the shallow sea of course must be filled up by the other water, and this must come from the coastal stretch southward and northward of the shallow sea above the submerged promontory. Here, it is true, you find the water of the "cold swell," but the way it must take as surface water before reaching the Abrolhos is much longer than the straight line from the coast to the isles. Furthermore, the rapidity of the drift of this surface water becomes lessened by the barrier formed by the isles and their many reefs only just below the surface; this barrier has only comparatively narrow and for the greater part very shallow passages for this drift. The time during which the originally cold water stays as surface water above the submerged Abrolhos promontory is comparatively long. During the intense heat in the summer time when the seaward winds causing the "cold swell" are generally prevalent, this time must be sufficient to

bring the water to the temperature necessary for the development of the coral reefs.

This discussion of the problem concerning the striking tropical character of the Abrolhos represents, of course, only an attempt to its solution. A definite statement of the causes of these circumstances cannot be made before a careful examination of the sea-currents has been made and the different temperatures of the waters in this district are fully known.

List of Publications Received.

Geological Survey. Bulletion No 29.

The Victorian Journal of Agriculture. Vol. VI., parts 1 to 4.

Botanic Gardens and Government Domains Report, 1906, Sydney.

The Forest Flora of New South Wales. Parts 28/30.

Bulletin of the Royal Botanic Gardens, Kew.

Records of the Botanical Survey of India. Vol. III., No. 4.

Bulletin du Museum National D'Histoire Naturelle, Paris.

Boletin del Cuerpo de Ingenieros de Minas, Peru. No. 53.

Food Habits of Grosbeaks, W L. Atee, U.S.A.

Adelaide Public Library, Museum and Art Gallery Report for 1906-7.

Birds that eat Scale Insects, W. L. Atee, U.S.A.

North American Fauna, No. 26.

On some Natural Grafts between Indigenous Trees, J. H. Maiden.

Century of Botanical endeavour, South Australia.

Some plant foods of the Aborigines, J. H. Maiden.

Some remarks on the Sand-drift problem, J. H. Maiden.

Some Australian Vegetable Fibres, J. H. Maiden.

List of Publications on Sale.

	Published.	
Mueller Botanic Society—		
No. 1	September, 1899 ...	Out of print
No. 2	October, 1899 ...	3/-
No. 3	November, 1899 ...	Out of print
No. 4	December, 1899 ...	Out of print
No. 5	January, 1900 ...	Out of print
No. 6	May, 1900	Out of print
No. 7	September, 1900 ...	3/-
No. 8	December, 1900 ...	1/6
No. 9	January, 1902 ...	3/-
No. 10	December, 1902 ...	1/6
No. 11	April, 1903 ...	1/6
West Australian Natural History Society—		
No. 1	May, 1904 ...	1/6
No. 2 ...	May, 1905 ...	1/6
No. 3	June, 1906 ...	1/6
No. 4	November, 1907 ...	1/6
No. 5	July, 1908 ...	1/6

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